Vol. XLIV. DECEMBER, 1900.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

TRANSACTIONS.

NOTE.—This Society is not responsible, as a body, for the facts and opinions advanced in any of its publications.

No. 880.

RECENT STADIA TOPOGRAPHIC SURVEYS: NOTES RELATING TO METHODS AND COST.

By WILLIAM B. LANDRETH, M. Am. Soc. C. E.

PRESENTED APRIL 4TH, 1900.

WITH DISCUSSION.

Surveys to determine the location of possible reservoirs and conduit lines for furnishing water for the summit level, or Rome level, of the proposed Deep Waterway on the Oswego-Mohawk-Hudson route were made under the direction of the Board of Engineers* on Deep Waterways, between August 1st, 1898, and June 1st, 1899. George W. Rafter was Chief of the Water Supply Divisions, with J. Y. McClintock, H. F. Northrup and the writer, Members, Am. Soc. C. E., as Assistant Engineers.

Mr. McClintock was in charge of the surveys on the feeder line from Carthage to Rome, N. Y. Mr. Northrup was in charge of the base-line surveys on the Salmon and Black Rivers, and of the topographic work on the latter stream near Carthage. The writer was in charge of the topographic work on the Salmon River, on the Black River beyond the limits of Mr. Northrup's survey, and on a portion of the feeder line, as a branch of Mr. McClintock's main party. Mr. B. E. Failing was

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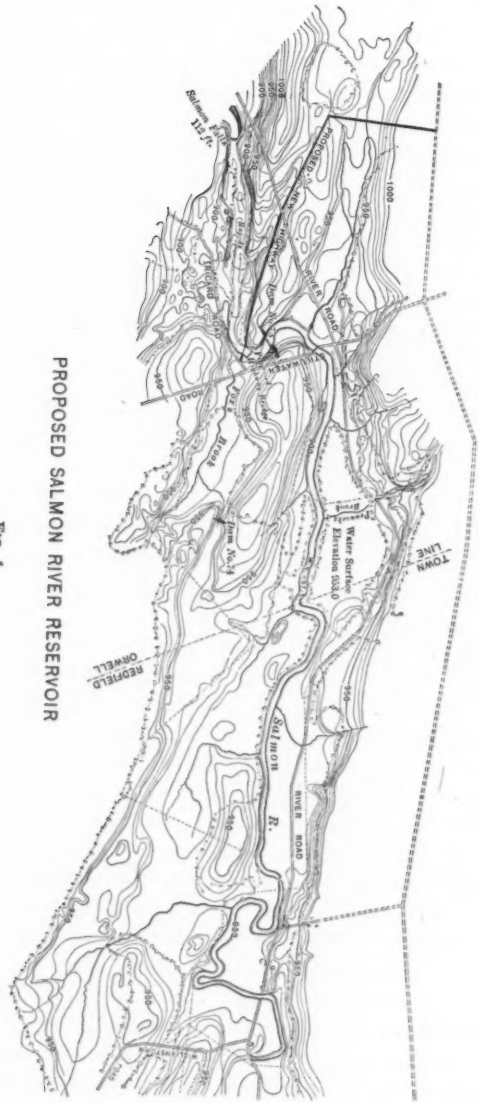
PROPOSED SALMON RIVER RESERVOIR
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Water Surface Elevation 1040
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Fig. 1.

transitman, and Mr. J. T. Parsons in charge of the office and map work, on the writer's party.

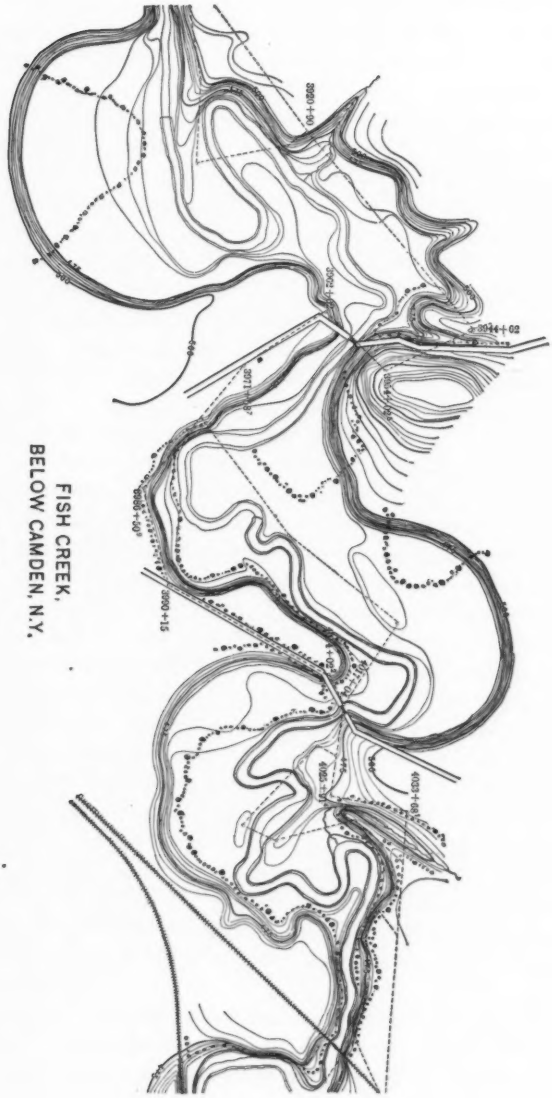
Party and Outfit.—The topographic party was composed of an assistant engineer in charge, a transitman, a recorder, three or more stadia rodmen, a draughtsman, a computer and two or more axmen. When running spirit levels, Mr. R. L. Burns, head stadia rodman, was detached from the main party for that purpose.

The outfit consisted of a transit fitted with non-adjustable stadia hairs, its horizontal limb reading to 20 seconds, and vertical arc to single minutes, one stadia rod for each rodman, a Y-level and rod; a large canvas umbrella, a tin megaphone, a 100-ft. steel tape, and the necessary office outfit of drawing table, instruments, etc. The whole outfit had been in use previously on the surveys of the main line of the Deep Waterway.

Field Work.—The method used in the topographic field work was that generally adopted on surveys where the distances are taken by stadia. The assistant engineer selected the base-line points to be occupied, and located the forward stadia points on the circuits, so as to cover the territory fully, and the party followed as closely as possible. Each rodman was given a particular class of objects to locate; one following the streams, another taking contour points, another the roads, buildings, woods, etc.

Each rodman worked independently, but when convenient all were kept on the same side of the transit, to facilitate the reading and plotting of the azimuths. An early trial was made of the method of placing all the rodmen on one azimuth, taking readings to each, and then moving all of them ahead to another azimuth; but it was soon abandoned as being productive of vexatious delays.

In working on streams of considerable size a circuit was run along one bank, and both slopes were worked from it, the party of rodmen being divided between them. Wooded gorges were worked from circuits on the top of each bluff, each slope being taken from the circuit on the opposite bluff. When the large streams were frozen, a circuit was run on the ice, and both banks were located therefrom. Crooked unfrozen streams were located from a circuit crossing them at the bends, with rodmen on each bank, the remainder of the party crossing from point to point in a boat. Long wooded slopes were taken from circuits along the top and foot thereof, and from short circuits con-



FISH CREEK,
BELOW CAMDEN, N.Y.

FIG. 2.

necting them, and so spaced as to cover the territory fully. Two corners of each building were generally located, the rodman measuring the other dimensions with his rod and giving the data to the recorder when passing him.

All streams, roads, buildings, outlines of woods, town and county lines and changes of slope were located. The contour interval on the surveys of the Salmon and Black River reservoirs was 10 ft., and on the Fish Creek feeder line 5 ft., with a 2-ft. interval on 2 square miles near the dam site on the Salmon River.

In rough ground the assistant engineer made field sketches on stiff-backed pads of cross-section paper, upon which governing points were located and numbered to correspond with the numbering of the shots locating them. It was found that the making of full sketches on all kinds of territory greatly retarded the progress of the field work without a corresponding gain in the rate of mapping.

Office Work.—At the close of each day's field work the field party reduced and checked the day's stadia readings and vertical-angle elevations, and the office force calculated the latitudes and departures of the stadia circuits. Two or more field books were in use at one time, the recorder changing books each day and leaving the book of the previous day for the use of the office force.

The mapping sheets were of heavy mounted white paper, 45 x 32 ins., with a working limit of 37 x 25 ins. The base, sub-base and stadia circuit lines were plotted carefully by latitudes and departures, care being taken to locate the working borders of each sheet so that the mapped surface would be evenly balanced thereon.

The sheets were lettered, inked and tinted to correspond with the same class of work done by the United States Geological Survey. The scale of the Salmon River and Black River maps was $\frac{1}{10000}$, and of the Fish Creek map $\frac{1}{5000}$.

Description of Territory.—The work on the Salmon River consisted of a survey of the valley of that stream above the Salmon River Falls, for a possible reservoir site. For a mile above the falls the gorge of the river is from 400 to 500 ft. wide with steep banks from 75 to 100 ft. high.

At the head of the gorge the valley widens out, forming flats from 1 to $1\frac{1}{2}$ miles wide, which extend about 10 miles up stream.

The river flats are 900 to 910 ft. above tide water, the survey cover-

PROPOSED FEEDER LINE FROM
LOWER BLACK RIVER
CAMDEN
Regulating
Gates
Flood Water Channel
Mud
River
Cooper River
Pump
Station

FIG. 3.

ing the country up to the 970-ft. contour. About 65% of the area surveyed is covered with small second-growth timber and swamps. The north slope of the valley is an unbroken range of hills, but the south slope is broken, necessitating the careful location of, and spirit leveling over, several long dike sites. A range of partly wooded hills, from 50 to 75 ft. high runs lengthwise of the valley on the south side of the river, for a distance of 5 miles, with dense swamps between it and the south side. The village of Redfield, having a population of about 500, came within the limits of the survey.

The survey of the Fish Creek Valley extended from 2 miles above the village of Williamstown to 2 miles below the railroad station at Taberg, a distance by rail of 21 miles. The survey covered the flat portion of the valley and the side slopes and tributary streams to an elevation of 75 ft. above the stream. The ground covered was mostly grazing and farm lands, 40% of which was timbered. Below the village of Camden the stream runs in a crooked gorge from 200 to 600 ft. wide, having steep wooded walls from 75 to 150 ft. high, cut from an open plain. The villages of Williamstown, West Camden, Camden and McConnellsville lie within the area covered by the survey.

The survey for a reservoir site on the Black River covered the valley of that stream between the villages of Carthage and Lyons Falls, up to the 790-ft. contour. At Carthage the sides of the valley approach to within 500 ft. of each other, forming a natural dam site, with rock at a reasonable depth. Above Carthage the valley widens out, until at Castorland, 10 miles up stream, it is 8 miles wide. Opposite the village of Lowville, 19 miles from Carthage, the valley begins to narrow up, and at Lyons Falls, 40 miles from Carthage, the sides close together, forming falls 65 ft. high. Three large streams enter the valley from the east, forming long tributary valleys.

The river flats lie mostly between the 730 and 740-ft. contours; the river being canalized between Carthage and Lyons Falls, with dams and locks at Otter Creek and Bushee's Landing.

About 25% of the area covered by the survey is wooded, and the east side is partly covered with granite boulders, ranging in size from that of a barrel to that of an average city block.

An area of 15 sq. miles above the 790-ft. contour was surveyed for a relocation of the Black River Division of the New York Central and Hudson River Railroad, between the villages of Carthage and Lowville.

Accuracy of the Surveys.—As the use to which the finished maps were to be put did not call for great accuracy in the surveys, it was not sought. The stadia circuits checked within 15 ft. in latitudes and departures, and within 0.50 ft. in elevation, with a permissible limit of 1 ft. in the latter. The error on closure in the stadia circuits was from 1 in 1 200 to 1 in 1 400, their length varying from ½ mile to 8 miles. A 30-mile circuit of spirit levels closed within 0.09 ft., being within the limit of error allowed on the United States Geological Survey.

Rate of Progress and Cost.—Table No. 1 gives the rate, area covered, cost per square mile, and other data regarding the entire work.

TABLE No. 1.—Rate, Cost and Other Data of the Three Surveys.

Survey.	Dates.	Number of days worked.	Set ups.	Shots.	Miles in stadia circuit.	Old base line occupied. Miles.	New base line. Miles.	Spirit levels, in miles.	Area, in square miles.	Square miles per day.	Cost.			
											Field work, per square mile.	Map work, per square mile.	Total, per square mile.	Total.
Salmon River.	1898, Oct. 22d, Dec. 9th.	47	771	3 838	53.97	25.85	.....	1.92	15	0.32	$ 66.00	$ 14.00	$ 80.00	$ 1 200.00
Fish Creek.	1898, Dec. 13th, 1899, Feb. 3d.	44	451	11 776	56.13	24.87	.....	.....	19	0.45	54.00	25.00	79.00	1 500.00
Black River.	1899, Apr. 4th, May 27th.	47	600	11 166	138.48	34.40	17.80	56.66	85	1.81	16.50	7.00	23.00	2 000.00

The cost includes the salaries, maintenance, traveling expenses and supplies for the entire party, from the time of leaving the main office until the completion of the finished maps.

The cost of the base-line surveys for the Salmon River and Fish Creek work, and for one-third of the Black River, is not included in the cost as given. The area given in the table is that covered by the writer's party. The variation in the cost and rate per square mile on the several surveys is probably caused by the different conditions of weather, foliage and territory covered by them, and the increase for mapping on the Fish Creek survey is traceable to the use of a small contour interval and a large map scale.

DISCUSSION.

Mr. Low. EMILE LOW, M. Am. Soc. C. E. (by letter).—This paper recalls to the writer two topographical surveys made by him several years ago. One, a survey of Prince's Flats and vicinity, Wise County, Va., and the other, a portion of the property of the Mathieson Alkali Works, at Saltville, in Smyth and Washington Counties, Va.

Prince's Flats is now called Norton, and is the junction of the Norfolk and Western and Louisville and Nashville Railroads. It comprises a stretch of land between the Goest's and Powell Rivers, which streams rise to the north of the town, flowing southward almost parallel to one another only a few miles apart, and at Norton turn, the former flowing to the east, the latter to the west.

At the time of the survey, part of Prince's Flats consisted of a little cleared land, the remainder and the adjoining country being a virgin forest and a howling wilderness. The Norfolk and Western Railroad Company had obtained an option on the land, which had been selected for a town site and junction point. Before acquiring the land the company desired to have a topographical survey made, and this duty was assigned to the writer. The option had only a short time to run, and it became imperative to make the survey and map in the shortest possible time. The survey was made in one month by a small party organized for this purpose and consisting of an assistant engineer, transitman, chainmen, back flag and axemen.

The area to be surveyed was about 2 miles long and nearly $\frac{1}{2}$ mile wide, and consisted of several tracts of land, on one of which the boundary line had been run out by a local land surveyor. The territory was quite rugged, the difference in elevation between the lowest and highest points being about 800 ft. Many of the slopes ranged from 30 to 45 degrees.

A wagon road ran through the property from one end to the other, cutting it into two nearly equal parts, and it was decided to use this for the location of a base line. A transit line, marked by stakes at 100-ft. intervals, was run along the road, and from this base line, especially on the north side, spur lines were run up the various water courses and also along the tops of ridges and crests. On the south side additional base lines were run, generally parallel with the main base. The boundary lines were also re-run, and on all lines stakes were placed at 100-ft. intervals. Nearly all the lines were carefully levelled over with a wye level, and elevations of all stations were taken, as well as of intermediate points, where necessary. A few of the auxiliary lines were run by a second party, which happened to be on the ground at the time, making surveys for the proposed railroad.

After the levels had been run, the topography was taken. This

included all the natural as well as the few artificial features which existed, also the contours, which were taken at 5-ft. intervals. Mr. Low.

The contours were taken by means of a hand or Locke level, the actual elevation ending in 0, and 5 ft. being ascertained on the ground and the distances from the center line noted. All measurements and observations were taken on lines at right angles to the base line. Some of the cleared areas were surveyed by the stadia method, in much the same manner as outlined in the paper.

The work of running the base lines, taking the levels of the same and the topography, so-called, was all done by one and the same party, each part of the work being taken up in regular sequence. The plotting was not done in the field, but at a neighboring farm house, on an improvised drawing table, after the base lines had been run, and while the levelling and topographical work was in progress.

The methods used in this survey gave very close results, it being especially desired that the location of the contour lines should be quite accurate, it being the intention to utilize the survey in laying out the town site, later on. A less accurate survey would have necessitated a second survey as a basis for laying out the streets. The streets were laid out several years after the survey was made, and it may be of interest to note, that very few, if any, changes or variations from the paper projection were required, showing remarkable accuracy in the contour work, which is especially noteworthy, when it is recalled that the area was densely wooded and covered with a thick growth of underbrush and laurel. The surveyed area comprised about 2 sq. miles, and the cost of the survey approximated $600, or $300 per square mile.

The other survey was that of a portion of the lands of the Mathieson Alkali Works, at Saltville, Va. This land formerly belonged to the Holston Salt and Plaster Company, a corporation engaged in the manufacture of salt. The Mathieson Alkali Works secured the property for the purpose of erecting thereon a plant for the manufacture of soda-ash and allied products. The contemplated works were to be very extensive and to employ a large force of men. As the old company had no maps of their property, on which the various salt furnaces, salt wells, houses and other improvements were located, the new company decided to have a complete topographical survey made, and this duty devolved upon the writer.

The survey generally comprised the valley of the Mill Spring Branch, as the stream was called locally. In this valley were situated the salt wells, and along the edges the various improvements, the whole valley being rimmed in by hills nearly 300 ft. high. The Saltville Branch of the Norfolk and Western Railroad skirted the west side of the valley. The survey also included part of the valley of the Holston River, on the banks of which the works of the company are located.

Mr. Low. In this case, also, it was desired to have an accurate survey of the property, and especially one which would show the true location of the contour lines. It was an ideal piece of country for a stadia survey, being entirely devoid of timber, the land not occupied being used for grazing cattle. Owing to the many artificial features involved, it was not considered advisable to use the stadia method, but to use instead that generally adopted on railroad surveys.

As at Prince's Flats (or Norton), base lines, marked by stakes set every 100 ft., were run in suitable and selected places. For instance, one was run up the middle of the valley, another along the railroad track, and others were run along the different highways, along the foot of the hills which skirted the valley, some higher up the hill sides, and some along the tops. Care was taken to run lines wherever possible along the ridges or high ground and as nearly as possible at right angles to the slopes. Spur lines were run where necessary along small streams and up ravines. All lines were run with a transit, and, in all but a few instances, formed closed circuits, which usually closed exactly or with a variation of a few minutes only. Each line was marked with a distinctive letter, for the purpose of identification on the ground.

Levels were run over these lines, the elevations of all stations being taken. The levels checked closely, the variations not exceeding a few hundredths of a foot.

The topography was all taken by the offset method, that is, on lines at right angles to the bases, and at the regular stations, placed, as stated, at 100-ft. intervals, and in a few instances at 50-ft. intervals.

All buildings of every kind were located, two measurements to each being taken, one the distance from the base line on range of one of the sides of the building to the corner, and the other from the same corner to the nearest station, the station and plus, where the range cut the center line, being, of course, also noted. The size, character, etc., of the building was also noted. The contours were taken, as at Prince's Flats, by a hand level.

The maps were plotted to a scale of 200 ft. to 1 in., or $\frac{1}{2400}$. The map sheets were 19 x 24 ins. in size, fitted together at the adjoining edges by crosses. The lines were plotted by means of a large paper protractor, using a standard meridian, to which the lines were referred. The main base line, extending from the Holston River to Buena Vista, a distance of about 3 miles, was checked carefully by means of latitudes and departures. As nearly all the other lines were on closed circuits, tied to the main base, the plotting could be checked in those instances, and it usually closed remarkably well. Upon the completion of the maps, a tracing of the whole area was made.

The area surveyed was about 3 sq. miles. The cost was about $900, or $300 per square mile. This is hardly a fair way to express the cost, as

the areas were comparatively small, and, also, on account of the large amount of detail taken, which is not the case in making surveys covering large areas, devoid of many artificial features, where only salient points are taken and the intervening portions sketched in or interpolated. Mr. Low.

JOHN F. WALLACE, President, Am. Soc. C. E.—The speaker was, for a short time, Vice-President and Manager of the Mathieson Alkali Works. One of the first pieces of information which he desired was a map showing the location and physical features of the property, and the results of Mr. Low's topographic survey were brought to him. Mr. Wallace.

The company owned from 13 000 to 14 000 acres of land, and had established, on the banks of the Holston River, a plant for the manufacture of soda-ash and its allied products. The total amount invested in plant and machinery was about $3 000 000.

The works were laid out originally by an English engineer, who had carried out the idea of the English industrial village. Each class of employees had its own settlement. The superintendents of departments had one section of a valley to themselves; the carpenters and the foremen of certain departments had another valley; the laborers in certain parts of the process still another valley; and the ordinary laborers another. The location of the buildings, the side-tracks, the drainage and other improvements, which were being considered and discussed continually, made a map of this kind an essential feature of the economical management of the property.

For the area covered, the speaker has never known of a more complete or accurate topographic survey than that by Mr. Low. He has had occasion to test it in innumerable ways, and, to his pleasure, has never found any errors. In the consideration of various projects for the development of the property, the location of roads, side-tracks, trestles, and apparatus to take care of the waste products, etc., he was able to make profiles in any desired direction, and the assistance given by the information embodied in this survey was so great that the speaker has always felt indebted to Mr. Low for it, and takes this opportunity to pay him a tribute. A great many engineers, like Mr. Low, spend their lives in obscure sections of the country, and we never hear of them. The faithfulness with which they carry out their work is never known. It is with pleasure, therefore, that the speaker calls attention to the accuracy of this particular survey.

HENRY B. MAGOR, Jun. Am. Soc. C. E.—The speaker was engaged in making the survey for the Hankow and Canton Railway, in China, of which William Barclay Parsons, M. Am. Soc. C. E., was chief engineer. Before sailing for China it was a question as to what kind of a survey, or, in fact, whether any survey whatever, could be made. Mr. Parsons, however, decided that a stadia survey was the only one Mr. Magor.

Mr. Magor. practicable. The party consisted of a chief of party, a topographer, an instrument man and two rodmen.

Before leaving Hankow it was considered absolutely necessary to check all the instruments and measure the rods. The latter was done by laying out a long base line on the Bund (the principal street in Hankow). With the assistance of some of the native policemen, and with three days' work, the subdivision of the rods was made exactly right. This was an important preliminary as the readings on the survey were not to be checked, and if the rods had not been correct there would have been a large cumulative error in the total length of the survey, 742 miles.

Stadia readings were taken for the distances, and the levels were taken by stadia readings and vertical angles, and the courses from the compass. The distance was covered in 75 working days, making an average of about 10 miles a day.

At the beginning of the survey a sight was taken on a pagoda, the latitude and longitude of which had been accurately determined to seconds by the Customs Department. At the end of the survey a sight was taken on another pagoda, the location of which had also been similarly determined. The latitudes and departures were then worked out and the total distance checked within less than 2 000 ft., or less than $\frac{1}{2}$ mile in 742 miles, which shows how accurate a stadia survey can be made.

The sights averaged about 1 500 ft., but one (when it was necessary to get away from a crowd in a hurry) was as great as 5 500 ft. Whenever it was possible, solar observations were taken to determine the declination of the needle. The first reading was 45 minutes west, and zero, or the magnetic meridian, was passed when about three-quarters of the distance had been traversed. Thus, fortunately, there were practically no corrections to be made in reckoning the latitudes and departures.

The levels, of course, could not be expected to check, in fact, no attempt was made to check the readings for elevation. The line was merely run from one point to another, the object in taking any levels whatever was to determine any particular gradient over a summit, and this, of course, was accomplished satisfactorily. The levels, however, checked reasonably well with the barometric readings on the summit, which was about 1 000 ft. above the sea; but neither of these results could be relied upon, as they were only approximate.

The stadia rods were 15 ft. in length, and in measuring very long distances half the wire interval was used and then the remainder was determined by the gradienter. Corrections of the distance for differences in elevation were not made. At certain places where the vertical angle was great, the correction of the distance was computed, but was so small that it would have been of no importance on a survey of this kind.

R. S. Buck, M. Am. Soc. C. E.—In the Government survey of the Red River it was endeavored to limit the length of the sights to about 600 or 700 m. The longest sight was about 1 000 m., but in such long sights there was a likelihood of considerable error. Mr. Buck.

All the speaker's stadia work has been done in level country, and he would like to inquire as to what extent corrections for distance are applied in making surveys in very hilly country.

Henry Goldmark, M. Am. Soc. C. E.—In the work in the Rocky Mountains, with which the speaker was connected, the stadia was only used to a small extent. John Q. Barlow, M. Am. Soc. C. E., did the instrumental work and made some very rapid surveys by that method He also surveyed some of the auxiliary reservoirs (not yet built) of the Ogden power plant by stadia, but the principal reservoir site was surveyed by the ordinary railroad methods, that is, by base lines and by secondary lines at right angles to these bases, all elevations being taken with a level. Mr. Goldmark.

There is no doubt that the stadia method would have been much more rapid and economical than the method adopted for that survey, and would have been sufficiently accurate. The surveys were very good, but the speaker has always considered them as more expensive than was necessary.

A. J. Himes, M. Am. Soc. C. E.—In making the United States Deep Waterways Surveys for a 30-ft. canal along the Oswego-Mohawk route, the territory was divided into two parts, known as the Eastern and Western Divisions, and the survey of each part was made by a separate corps of engineers. The dividing line was at Herkimer, a few miles west of Little Falls. Mr. Himes.

The route, on the Western Division, followed the Oswego River, Oneida Lake, Mohawk River and connecting lines, a total distance of about 91 miles. The work on this division included the necessary harbor surveys at Oswego, soundings in Oneida Lake and the various streams, the triangulation of Oneida Lake, covering an area of about 78 sq. miles, a complete system of test borings and about 120.7 sq. miles of topography. The topography was taken with the stadia, in accordance with instructions issued by the United States Board of Engineers on Deep Waterways.

A base line was measured along the route, and Oneida Lake was covered with a chain of quadrilaterals. This base line and triangulation formed the foundation of the survey.

Method.—The manner of taking the topography was: To start from an instrument point on the base line, with the base-line azimuth, and run a circuit through the territory to be covered, returning, generally within a distance of 2 miles, to the base line and checking the azimuth on the nearest base line point.

The courses in the circuit were all measured with the stadia, except-

Mr. Himes. ing those belonging to the base line, which necessarily formed a part of the closed circuit.

The distances and vertical angles were read twice, once as a foresight and once as a backsight, and the mean of both was used in plotting.

As each instrument point was occupied in running the circuit, readings were taken all around the circle, on all objects of topography, natural or artificial, which could have any bearing upon the proposed plans and estimates.

A sufficient number of readings was taken to permit the development of contours having a vertical interval of 2 ft.

All buildings, roads, railoads, property lines, ditches, canals, streams, high-water marks, orchards, swamps and rock outcrops were located, and notes were made of the character of the soil and substrata where exposed.

Sketches were carefully made in the field books, and were found to be of great service in plotting. Each stadia reading was numbered, beginning each morning with number one, and the locations of the principal readings, with their numbers, were shown on the sketches.

Each party was supplied in advance with a list of data for use in the locality where it was at work, which included the number, elevation, latitude and departure of all base-line instrument points, the true azimuth of the base-line courses and the approximate boundary of the territory to be surveyed.

With this information, it was an easy matter to find a starting or a closing point for a circuit, and to check the circuit after it was run.

In order to avoid complications in the adjustment of circuits for plotting, they were made as simple as possible. Along the base line, their length was limited to 2 miles. A secondary circuit was allowed to start from and return to a primary circuit, but no circuit was allowed to start from one circuit and close on another, or start from a circuit and close on a base line, save in exceptional cases.

Checking Survey.—In the beginning of the survey, the field work was checked by having each party plot its own work roughly on protractor sheets. At that time there were only two stadia parties at work. They were located very near together, and the checking was fairly well done. It was found, however, that to do the work thoroughly would require the addition of a draftsman and a computer to each party. Even with this change it would have been difficult to keep the checking close up to date, because the book which was in the field during the day was always needed at night for reducing the readings and completing the notes, so that the draftsman either had to be a whole book behind in his work, or else the field party must work first in one book and then in another, either of which methods was very objectionable.

Working Maps.—After the survey had been in progress for a time, it was decided by the Board that since working maps were needed,

Mr. Himes.

they could as well be made by the field parties instead of the plotting of the protractor sheets, thus saving the labor on one set of maps and securing the necessary check on the survey and a complete set of working maps at the same time.

It was desirable to plot the base line on these working maps by latitudes and departures, and, as they must be figured, it became convenient to check the stadia circuits by figuring their latitudes and departures and comparing results with those of the base line at the closing station.

The method pursued thereafter was, therefore, to check the stadia circuits by latitudes and departures immediately when closed, to send a book, when completed, to the headquarters of the survey, where the numerical work contained therein was first checked and the notes then plotted and errors or omissions reported back to the field for correction. The work was so divided among the stadia parties that each party could remain long enough in one locality to fill several books, and it was very seldom that a party had to go back to a previous location to look up errors.

After the winter work on Oneida Lake was completed, the force was so large, numbering for several months nearly 100 men, and the work was so scattered, that it would have been impossible to maintain a thorough control of it if the mapping had not been centralized and reduced to a system as above described.

Each night, after the men had returned to their boarding places and eaten their supper, the notes taken during the day were reviewed, the stadia measurements, when necessary, were reduced to the horizontal and the differences of elevation computed. The latitudes and departures of the circuit courses were figured, and if a circuit had been completed, the latitude and departure of the closing station were compared with its latitude and departure as given in the base-line notes. By this means, when errors occurred, they were always discovered promptly and corrected before they could create any confusion in the office work.

TABLE No. 2.

Error.	No. of circuits.	Maximum length of circuit.	Minimum length of circuit.	Average length of circuit.
Exceeding $\frac{1}{100}$	2	4 240	3 162	3 701
Between $\frac{1}{400}$ and $\frac{1}{700}$	4	26 842	1 486	13 076
Between $\frac{1}{700}$ and $\frac{1}{1000}$	10	31 000	2 140	12 737
Between $\frac{1}{1000}$ and $\frac{1}{1500}$	7	7 015	1 813	4 779
Between $\frac{1}{1500}$ and $\frac{1}{2000}$	6	56 048	2 589	21 163
Between $\frac{1}{2000}$ and $\frac{1}{3000}$	7	31 027	4 597	11 555
$\frac{1}{3105}$	1	.....	.....	16 522
$\frac{1}{5014}$	1	.....	.....	5 324
$\frac{1}{10085}$	1	.....	.....	4 385
$\frac{1}{11104}$	1	.....	.....	13 683
Average error $\frac{1}{1085}$	40	56 048	1 486	11 732

Mr. Himes.

Precision of Work.—In order to show the degree of precision which was attained with the stadia, all circuits throughout the whole work which were closed on their starting points have been reviewed and their closing errors computed. The results are shown in Table No. 2, from which it may be seen that the error can readily be kept below $\frac{1}{700}$.

The error in elevation seemed to bear no relation to the length of the circuit. It seldom exceeded 1 ft., and was generally less than 0.5 ft.

Organization of Party.—A stadia party usually consisted of five men; an instrument-man, a recorder and three rodmen. Sometimes a laborer was added to a party, temporarily, for the purpose of cutting brush or rowing a boat.

The instrument-man was required to direct the work of the party and attend to its needs. He selected the boarding place, paid incidental expenses and rendered accounts for board, team hire and sundries to the Assistant Engineer. He also made weekly statements of the amount of work done, and kept a journal in which were recorded all events which might have a bearing on the progress of the work, such as storms, high water, the transfer of men from one party to another, and the loss of tools.

In the field he either kept notes or ran the instrument and had the general direction of the operations of the party.

The recorder acted as an assistant to the instrument-man, recording notes, running the instrument or taking charge of the party, temporarily, when the instrument-man desired to make a reconnoissance, or for some other reason was separated from the party.

The work of the rodmen was to carry the stadia boards in the field, to select points where readings were to be taken, and report to the instrument-man any information they might obtain which would be of value to the survey.

An effort was made to allow each man in the party to acquire as much experience as possible, and for that purpose the recorder and instrument-man exchanged work occasionally with the rodmen. While the progress of the party was hindered a little at such times, it is believed that by increasing the interest of the men in their work the final result was benefited.

Field Notes.—Each instrument-man was required to keep his notes so clearly that any stranger, not familiar with the work, could read them readily. For this purpose, each book contained an index and a brief synopsis of its contents, and all notes copied from other books were thoroughly cross-referenced. For instance, when a stadia circuit was started from a base-line instrument point, a reference was made in the notes to the book and page of the base-line notes where the station was recorded, and also to the place in the level notes where the elevation was found.

No erasures were allowed in the notes, and the date, the number of the instrument, and the names of the observer and note-keeper were always recorded. Mr. Himes.

After the computations had been made, references were made to the computation books where the figures were recorded.

It was found nearly impossible to keep the notes written up and the reductions made by evening work, so every stormy day was used to catch up, and, on rare occasions, the whole party remained inside for a day to work on the notes.

Practice developed many convenient details in doing the work, which aided much in the interpretation and plotting of the notes. Some of the features of the work which have been stated were not begun until the work had been in progress two or three months, as they were the outgrowth of experience.

Instruments.—The instruments used were the usual railroad transits with stadia wires. There were two made by Buff and Berger, two by Seelig, and one by Heller and Brightly. In the latter instrument the wires were adjustable, in the others they were fixed, but in all cases the value of the interval was determined, and the rods graduated accordingly, no attempt being made to adjust the wires in the Heller and Brightly transit.

Reduction of Readings.—The rods were graduated and the reductions made according to the formula deduced by S. W. Robinson, M. Am. Soc. C. E., of Michigan University. The tables computed according to that formula by Alfred Noble, M. Am. Soc. C. E., and Mr. Wm. T. Casgrain were used at first in making the reductions. Later, charts for doing the work were furnished by the Board, and their use greatly lessened the amount of necessary labor.

FIG. 4.

Graduation of Rods.—The style of graduation used on the rods was found to be especially adapted to the work, and is, therefore, exhibited in Fig. 4. The features of especial merit are, its simplicity and absence of fine detail, which avoids confusion, and the use of sharply-defined angles for divisions, which permits very precise readings.

The rods were 4 ins. wide and 12 ft. long. The 5 and 10-ft. marks were painted red. Sights 2 000 ft. long were read very frequently on instrument points as well as for side readings.

Seasons.—The work was begun October 23d, 1897, and prosecuted continuously by one or more parties until its completion, November 5th, 1898. The work has been done in all seasons, in all kinds of weather, and in many kinds of country, including the wharves, buildings, bridges and canals in Oswego, the railroad yard in Utica, the irregular and thickly

Mr. Himes. wooded hills of Sand Ridge and the open, level plains of the Mohawk Valley.

As to the comparative merits of the seasons for taking the topography, it was found that July and August were the most unfavorable months, and that the best time is in the early spring or late fall, when the weather is cool, the trees are bare and there are no crops or heat waves to interfere with the sight or impede the progress. In warm weather the atmosphere is too unsteady to permit long sights, the foliage is thick, and obstructs the view, and the summer heat renders the traveling more fatiguing, so that the rodmen cannot cover as much ground.

The progress of the party is frequently dependent upon the speed with which the notes are recorded, and in extreme cold weather the progress is lessened somewhat by the difficulty of using a pencil with cold fingers. In other ways, no especial difficulty was experienced in the winter time. During the winter of 1897–98, the snow caused no more interference with the work than did the rain during the following summer.

The average number of days lost each month by the several parties, on account of storms, was as follows:

1897, October, 0.0; November, 3.5; December, 4.5.
1898, January, 1.0; February, 4.4; March, 1.4; April, 2.8; May, 4.7; June, 1.2; July, 0.7; August, 3.2; September, 1.5: October, 3.6.

Cost.—The cost of the stadia work per square mile, using the same items given by Mr. Landreth, viz.: salaries, maintenance, traveling expenses and supplies, was as follows:

Field work	$179
Mapping	101
Total	$280

There have been excluded from the area several swamps which were surrounded with stadia work, but not penetrated. Their aggregate area is 13.4 sq. miles.

The average number of readings per square mile was about 1 440, or 2¼ per acre.

The minimum average area covered per day by one party on a single piece of work was 0.058 sq. mile. The maximum was 0.257 sq. mile. The average area covered per day by one party for the whole survey was 0.123 sq. mile.

In computing these averages, holidays and other lost time has not been deducted from the total number of days in the field.

About 83% of the area was mapped on a scale of 1:5000. The remainder was mapped on a scale of 1:2500.

Mr. Himes.

The cost of mapping includes plotting soundings, test borings and triangulations. There were upwards of 12 sq. miles of soundings, and the cost of plotting these cannot be separated from the rest of the mapping. It would, perhaps, be more accurate to call the total area of mapping 133 sq. miles. The cost per square mile would then be $92. A vertical interval of 2 ft. was used in plotting the contours.

All elevations, determined either by sounding or with the stadia, were inked on the maps. This, it is thought, was not done in Mr. Landreth's work.

Conventions furnished by the Board were followed throughout the work, but while they were used sufficiently to show clearly the topography of the country, care was exercised to avoid everything in that line not wholly necessary, to the end that the maps might be a useful medium for an engineering study rather than an exhibition of artistic skill.

In making use of the foregoing data, it would be well to note that the maximum rate of progress was about four times the minimum. Also, in Mr. Landreth's data, the field work on Fish Creek for 5-ft. contours cost less than that for 10-ft. contours on Salmon River, while, on the Black River, the cost for 10-ft. contours was one-fourth of that on Salmon River.

It is surprising that on Fish Creek, where 620 readings per square mile were taken, the cost should be nine-elevenths of that on Salmon River, where 256 readings per square mile were taken.

On the Black River, Mr. Landreth took 131 readings per square mile, which is about one reading for every 5 acres. Eighty-five sq. miles were covered in that way. This small number of readings and the low rate of cost make it interesting to consider the cost of the United States Geological Maps, and to inquire whether work done in that manner would have served the purpose. In the New York State Engineer's Report for 1895, it is stated that the total cost of the United States Geological Maps in that State, prior to 1895, is at the rate of $10.62 per square mile.

It is noted in Table No. 1, that a large percentage of the work was taken directly from base-line stations. That practice was forbidden on the main surveys, it being considered that greater chances for error were afforded than where the topography was all taken from stadia circuits.

Considering the rapid movement of Mr. Landreth's party, it was undoubtedly better for him to use a large party and do the plotting at once.

The method of plotting outlined above was the outgrowth of conditions which had to be met, and should never be adopted without due consideration.

The results of the work appear to warrant a more general use of the stadia on preliminary surveys.

Mr. MacGregor. R. A. MacGregor, Assoc. M. Am. Soc. C. E.—In the survey of Baltimore, Md., the stadia method was used on more than 33 square miles. The maps were plotted to a scale of 200 ft. to 1 in., and all fences, roads, houses (with some details of the houses), contours at 5-ft. intervals, wooded areas, creeks, pasture and cultivated areas, etc., were shown.

The method used was somewhat similar to that described by Mr. Himes. The instruments were provided with fixed stadia wires; the horizontal and vertical circles were divided to read to 30 seconds, and the vernier of the vertical circle carried a level tube, each division of which had a value of 30 seconds.

The stadia boards were T-shaped in section and the figures were similar to those used on the United States Lake Survey. The meter was used as the unit of length on account of the convenience in using the tables for difference of elevation, which were those computed by Messrs. Ockerson and Teeple of the United States Lake Survey, and which give the elevation in feet for the distance in meters.

Everything was plotted in the field, the map being made complete in pencil before leaving the locality. The shots were taken and reduced by the recorder, and plotted by the draftsman, who stood behind him. The topographer in charge then did the sketching.

Each sheet contained ¼ sq. mile of territory, and had at least five, and sometimes a great many more, points plotted thereon, before being sent into the field. The co-ordinates of points and azimuths and distances between the points were given, and closed circuits were run between them. The circuits were computed in the field and no error greater than 1 m. was allowed, this being about the limit of accuracy in plotting to 200 ft. to 1 in.

Elevations were read and plotted to 0.1 ft., and the level runs usually checked within 0.1 ft. On a run of 4 370 m. the error was only 0.18 ft. between points determined by spirit leveling.

The average error of closure was about 1 in 700 between points determined by precise traverse methods in which the error was 1 in 10 000. On a traverse of 1 000 to 1 200 m. the error was occasionally 1 in 1 200. These ratios are all by actual calculation.

The cost of the 33.3 sq. miles was about $850 per square mile for the stadia field work alone. The average number of shots to the acre was about 10. The work done by the speaker, about 3 500 acres, averaged 18 acres per day. The maximum number of acres surveyed in a day was about 75, with 207 shots, the minimum a small fraction of an acre, as the character of the territory varied considerably. There were small clusters of houses on most of the sheets, but on one sheet in the most thickly settled portion, there were 840 houses and 4 000 shots. The number of shots per day averaged 180, with a maximum of 349, all being plotted and the sketching done.

General H. T. Douglas, M. Am. Soc. C. E., was Chief Engineer of the survey, and Mr. O. W. Connet was in charge of the topographical division. Mr. MacGregor.

KENNETH ALLEN, M. Am. Soc. C. E. (by letter).—The cost of topographical surveys is of little significance without full knowledge of the character of the ground, the extent of the survey, and such necessary expenses as transportation and board, which depend on the locality. Mr. Allen.

Of the remaining factors, the scale of the map, which generally controls the limit of error, is of prime importance. So that, when it is claimed that a certain survey was well conducted because costing less per unit of area than another, it means absolutely nothing. For this reason, such details as are given by the author are of value in enabling one to estimate the cost of similar surveys under similar conditions.

In connection with the recent investigations of the Baltimore Sewerage Commission, various topographical surveys were conducted by the writer, from which the following five are selected, data regarding the cost of which are given in Table No. 3, and are, perhaps, of sufficient value to place on record.

The ground being similar in Surveys I and II, a comparison of their costs is of interest in showing the economy of reading compass bearings and setting up on alternate points, where this is sufficient, and practicable.

A comparison of the cost of Survey I with the costs of Surveys IV and V shows the increased expense due to plotting on a larger scale and halving the contour interval, the territories being fairly open in each case, and I and V having but gentle slopes. It will be noted, too, that IV and V are quite limited in extent in comparison with the others, which in part accounts for their greater cost per square mile.

TABLE No. 3.

Survey	I.	II.	III.	IV.	V.
Contour interval, feet	5	5	5	2½	2½
Scale of map	800′ = 1″	800′ = 1″	400′ = 1″	200′ = 1″	200′ = 1″
Actual working days	13	21	61	16	14
Total area, square miles	2.04	2.75	4.83	0.823	0.733
Area per day, square miles	0.157	0.131	0.079	0.0515	0.0524
Salaries per square mile	$54.90	$78.00	$140.20	$323.61	$256.21
Expenses per square mile	11.91	16.49	28.54	30.73	13.50
Cost per square mile	$66.81	$94.49	$168.74	$354.34	$269.71
Estimated cost per square mile, including superintendence	.....	.....	186.57	363.18	284.01

All these surveys were made by stadia and vertical arc measurements, running in circuits between established points, and referred to benches established by the wye level. The bearings were determined

Mr. Allen. by the compass, except in Survey II, where the azimuths were turned off by vernier. The times given are for days worked only, and do not include time lost; while the costs given are for work in the field only, and do not include the map work done in the office. They do include, however, all expense for field work, including the plotting of the map on field sheets which were turned in to the main office and transferred by the draftsman to a sheet on which the lines or points of control had been plotted.

Surveys III, IV and V were made with considerable care and detail, being for the purpose of laying out filtration beds or plants for the treatment of the city's sewage.

Of Survey III, 47% was in timber, and 3% in marsh and water.

Of Survey IV, 12% was in water surface.

Of Survey V, 27% was in timber, 12% was in open marsh, and 6% was in water surface.

In Survey III the range of elevation was 125 ft. Some of the ground was quite rough and filled with a dense thicket of briar and underbrush. In the other areas the range of elevation did not, generally, exceed 40 ft.

The greatest error in closing the circuits of Survey III on the map, averaging about 1½ miles in length, was 80 ft., occurring in an unimportant place; the next was 30 ft., and the average 10 or 15 ft.

Two steel tape lines, which had been run through this area, were utilized as bases; while in Survey V, steel tape base lines were run from known positions determined by the United States Coast and Geodetic Survey.

The writer is interested in noting the use of a megaphone in the field. The means of communication between the rodman and the man at the instrument should be effective at the maximum distance and not liable to misinterpretation. A simple code of signals is believed to be preferable to verbal orders for directing the ordinary movements of the rodman, and for this purpose a whistle or small flag may serve; but there are times when some means of conveying fuller directions than can be done in this way is very desirable, and the megaphone may answer the purpose. Sight signals have the advantage of being effective where there are disturbing noises from winds, factories or waterfalls, while signals by sound may be preferable where there is more or less obstruction to the sight.

Mr. Fisher. WAGER FISHER, Jun. Am. Soc. C. E. (by letter).—The cost of the field work for topography with 10-ft. contour intervals on two territories, which were, respectively, 65% and 25% wooded, is given by Mr. Landreth as $66 and $16.50 per square mile. These results present an opportunity of determining, in a measure that is at least suggestive, how much the cost of such topography varies with the percentage of woodland.

Mr. Fisher.

The writer, having computed the cost of a similar survey made in the summer and fall of 1899 by the New York State College of Forestry* of their tract in the Adirondacks, in Franklin County, N. Y., submits the results in order that with others they may form a basis of comparison.

The territory was practically all wooded, and presented the usual difficulties of the mountainous and hilly country of the Eastern States. The area covered was 32 sq. miles, and, in the effort to find the cheapest method, both rectangular and irregular systems of stadia transit lines were tried. There were 172 miles of stadia circuit. The survey was made between July 1st and December 1st, 1899, but not continuously. Comparing the seasons, summer and fall, differences in foliage were largely counterbalanced by differences in weather. The cost of maintenance was about 41% of the total expense.

TABLE No. 4.

Survey.	Percentage of woodland.	Cost per square mile.
Black River	25	$16.50
Salmon River	65	66.00
New York State College of Forestry	100	85.00

Mr. Christian.

G. L. CHRISTIAN, Assoc. M. Am. Soc. C. E. (by letter).—The writer fully agrees with Mr. Allen that the cost of topographical surveys depends upon the character of the ground, the extent of the survey, the scale of the map, transportation facilities, board, etc. The season of the year is also a very important factor.

For instance, in the Middle Atlantic States, the work can generally be performed to much greater advantage early in the spring or late in the fall, especially if the district is heavily wooded.

In 1896 the writer made a survey of a 57-acre tract of land in Westchester County, N. Y., which the owners wished to subdivide. Most of the work was done during the month of July, and the weather was exceedingly hot and sultry.

Three-quarters of the tract was woodland, with much thick underbrush and heavy foliage. The land was much broken, and varied from a rise of 2 ft. in 100 to a rise of 40 ft. in 100, and had a total rise of 150 ft.

The transit lines (12 750 ft.) were first run so as to cover what seemed to be controlling points, such as along the tops of ridges, at the foot of hills, etc., stakes being set every 50 ft.; after which levels were carefully run over the whole line with a wye level, elevations being taken at each stake, and at intermediate points if necessary.

* Doctor B. E. Fernow, Director. Field work supervised by Professor H. N. Ogden, Assoc. M. Am. Soc. C. E., and Mr. William E. Mott, both of Cornell University.

Mr. Christian. From these lines and levels the 5-ft. contours were located on the ground, at right angles to the transit lines, with a Gurley hand level, an ordinary level rod and a steel tape.

The actual working time of the field party each day was from 9 A. M. to 5 P. M., with one hour for lunch. The work was 2 miles from the office, and transportation, consisting of a horse and wagon, was furnished each way.

The net cost of the field work, transportation, stakes, and mapping was $1.47 per acre, divided as follows:

Field work including transportation:

Running transit lines	$0.40	
" wye levels	0.19	
Five-ft. contours, with hand level	0.53	
Total		$1.12
Stakes		0.07

Mapping:

Plotting transit lines	$0.13	
" contour "	0.15	
Total mapping,		0.28
Grand total		$1.47

The map was plotted on a scale of 100 ft. to 1 in.

Mr. Rafter. GEORGE W. RAFTER, M. Am. Soc. C. E. (by letter).—As to the cost of the several surveys it may be remarked that, without a full statement, Mr. Landreth's tabulation is somewhat misleading. Thus the total cost of Black River survey was $3 815.47; Salmon River Reservoir, $2 459.05. The cost of Fish Creek Feeder is included in the general cost of feeder lines, which is $13 013.23. It should be understood that the cost of Fish Creek Feeder is for topographic work only; all expense for leveling of every kind is included elsewhere. An understanding of these facts gives to the author's results a somewhat different complexion than they would have if unexplained. The writer, however, wishes to accord Mr. Landreth very high praise. The Salmon River and Fish Creek surveys were largely made during severe winter weather, and are evidence of his great energy, as well as skill in this special line of survey.

Another matter which contributed to the success of the work may be mentioned. Each chief of party was required to report to the office at the end of each week exactly what had been done. These reports took the form shown in Table No. 5, which illustrates Mr. Landreth's work on the Salmon River Reservoir for the month of November. At the end of the month the weekly reports were compiled into a monthly report, and forwarded to the Board.

TABLE No. 5.

Mr. Rafter.

REDFIELD, N. Y., December 1st, 1898.

Report of progress on Survey for Salmon River Storage Reservoir for month of November, 1898.

By WILLIAM B. LANDRETH.

Date.	STADIA.		DISTANCE.		No. Days actual work.	Weather.	Character of ground.
	Stations.	Shots.	Stadia Line.	Base Line.			
Nov. 1	20	110	5 326	3 000	1		
" 2	26	147	6 942	5 400	1		
" 3	15	156	3 705	7 600	1		
" 4	18	146	5 234	3 200	1		
" 5	28	90	11 581	5 600	1	Rain.	
" 6	....	....	.....	.....	....		
" 7	22	51	5 285	4 300	1		
" 8	21	74	4 763	2 000	1		
" 9	22	38	4 719	2 090	1	Rain.	
" 10	16	20	3 072	.....	1	Rain.	
" 11	20	19	4 535	.....	1		
" 12	22	28	5 652	.....	1	Rain.	
" 13	10	9	3 754	.....	1		
" 14	22	27	11 834	3 500	1	Rain.	
" 15	22	44	7 845	.....	1	Rain.	
" 16	17	13	5 787	3 000	1		
" 17	25	20	13 275	.....	1		
" 18	20	57	13 501	3 000	1		
" 19	15	92	24 788	.....	1	Rain.	
" 20	21	37	9 075	.....	1		
" 21	17	65	6 225	14 800	1		
" 22	14	60	8 139	.....	1		
" 23	21	173	11 043	10 100	1	Snow.	
" 24	20	101	6 587	9 600	1		
" 25	....	....	.....	.....	....		
" 26	21	109	8 700	5 700	1	Snow.	
" 27	18	143	14 890	4 200	1		
" 28	17	158	3 838	14 400	1		
" 29	19	141	6 657	10 300	1		
" 30	23	63	8 420	14 700	1		
Totals....	552	2191	225 262 42.66 Miles.	126 490 23.95 Miles.	28	.....	Estimated: 35% Open, 65% Wooded.

Mr. Landreth.

W. B. LANDRETH, M. Am. Soc. C. E. (by letter).—Referring to Mr. Buck's inquiry regarding corrections for distance in stadia surveys in hilly country; the practice on the work described was to make corrections for distance on all readings between stadia points used in calculating circuits and to disregard them on all shots where the correction was less than 3 ft.

The stadia reduction diagrams used were so drawn that the approximate reduction could be noted at a glance and taken off closely if necessary with little labor. All elevations determined were noted on the maps, as in the general work of the U. S. D. W. Survey, and Mr. Himes has been misled regarding them by their having been omitted by the engraver from the illustrations accompanying the paper, owing to the very small scale used.

Mr. Landreth. The writer is unable to give an explanation for the variation in the cost of the three surveys that is entirely satisfactory to himself, but believes that the percentage of wooded area has a great influence on the cost of the surveys. On the Salmon River and Black River Surveys, with a 10-ft. contour interval, the former, with the larger percentage of wood, cost the most, while the Fish Creek Survey with a wooded area about midway between the others, but with a 5-ft. interval, cost 82% of the former.

The methods used on the U. S. Geological Survey could not have been used to advantage on the Salmon River and Fish Creek Surveys owing to the necessity of doing the field work in the late fall and winter, and it is doubtful if there would have been any saving in cost by using that method on the Black River Survey owing to the 10-ft. interval used, as compared with the 20-ft. interval on the Geological Surveys.

To avoid a possible misunderstanding of the items covered by the table of cost of surveys noted by Mr. Rafter, the writer would state that the cost of the following work is included in the amounts given: Salmon River and Fish Creek surveys, stadia field work and map work; Black River, base line and levels on two-thirds of the territory, stadia field work and map work on all the territory.